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Outcomes of urinary diversion after surgery for locally advanced or locally recurrent rectal cancer with complete cystectomy; ileal and colon conduit

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ABSTRACT

Introduction: Surgery for locally advanced rectal cancer (LARC) or locally recurrent rectal cancer (LRRC) may require total pelvic exenteration with the need for urinary diversion. The aim of this study was to describe outcomes for ileal and colon conduits after surgery for LARC and LRRC.

Methods: All consecutive patients from two tertiary referral centers who underwent total pelvic exenteration for LARC or LRRC between 2000 and 2018 with cystectomy and urinary reconstruction using an ileal or colon conduit were retrospectively analyzed. Short- (≤30 days) and long-term (>30 days) complications were described for an ileal and colon conduit.

Results: 259 patients with LARC (n = 131) and LRRC (n = 128) were included, of whom 214 patients received an ileal conduit and 45 patients a colon conduit. Anastomotic leakage of the ileo-ileal anastomosis occurred in 9 patients (4%) after performing an ileal conduit. Ileal conduit was associated with a higher rate of postoperative ileus (21% vs 7%, p = 0.024), but a lower proportion of wound infections than a colon conduit (14% vs 31%, p = 0.006). The latter did not remain significant in multivariate analysis. No difference was observed in the rate of uretero-enteric anastomotic leakage, urological complications, mortality rates, major complications (Clavien-Dindo≥3), or hospital stay between both groups.

Conclusion: Performing a colon conduit in patients undergoing total pelvic exenteration for LARC or LRRC avoids the risks of ileo-ileal anastomotic leakage and may reduce the risk of a post-operative ileus. Besides, there are no other differences in outcome for ileal and colon conduits.

Introduction

In approximately 10% of all newly diagnosed patients with primary rectal cancer there is local invasion of the tumor in surrounding structures. In patients who develop a local recurrence, which occurs in approximately 6–10% of all patients treated for primary rectal cancer, invasion in adjacent organs, such as the bladder and/or the organs of the reproductive system, is even more common [1–3]. Radical surgery is essential for cure and the achievement of a clear resection margin is the most important prognostic factor for overall survival in these patients [4,5]. To achieve a clear resection margin in patients with tumor invasion in the bladder, prostate or urethra, a radical approach is indicated, which often requires partial or complete cystectomy (i.e. pelvic exenteration). When a complete cystectomy is performed patients require a urinary diversion [6,7]. Historically there are several urinary diversions, but in current practice the most common urinary

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diversions are an ileal conduit (i.e. Bricker) or a colon conduit [8–11]. In both cases an isolated bowel segment (ileum or colon) is used as a conduit for the ureters, which is deviated through the abdominal wall as a urostomy. Both surgical procedures slightly differ due to the use of different bowel segments. An ileal conduit requires an ileo-ileal anastomosis, whereas in colon conduits an extra anastomosis is usually not required because the terminal segment of the descending colon can be used. Both procedures are associated with general surgical and urological complications. In addition, conduit specific complications may occur, such as metabolic changes or intra-abdominal complications of the urinary diversion, such as leakage of the uretero-entero anastomosis and ileus [8,12–14].

The aim of this study was to describe the short- and long-term complications associated with an ileal and colon conduit after surgery for locally advanced rectal cancer (LARC) and locally recurrent rectal cancer (LRRC) in a pooled cohort of two large tertiary referral hospitals.

Patient and methods

All consecutive patients who underwent a total pelvic exenteration with complete cystectomy for LARC or LRRC with formation of an ileal or colon conduit in the Catharina Hospital Eindhoven (CZE) or the Erasmus MC Cancer Institute (EMC) between January 2000 and November 2018, were identified from a prospectively maintained database. CZE and EMC are both tertiary referral hospitals in the Netherlands. Both centers have an experienced multidisciplinary tumor board (MDT) in which all patients diagnosed with rectal cancer are discussed and evaluated for optimal multimodality treatment. This tumor board includes dedicated surgeons, radiologists, radiation oncologists, medical oncologists and urologists. If indicated, gynecologists, pathologists and plastic surgeons participate in this meeting.

Data collection

All data on patient and tumor characteristics, (neo)adjuvant treatment, surgical procedures, perioperative variables, short- and long-term surgical and urological outcomes were retrospectively reviewed. All included patients were followed up for at least 30 days after surgery. Thereafter, follow-up was either conducted in the hospital in which the surgery was performed or in the patients' primary referring hospital. The present study was approved by both institutional local medical ethics committees (CZE; registration number: W19.031 and EMC registration number; MEC-2017-448).

Neoadjuvant treatment and surgical procedures

Patients were usually scheduled for neoadjuvant radiotherapy: short-course (25Gy) or long-course (50Gy) radiotherapy for LARC and re-irradiation (30Gy) or long course (50Gy) for LRRC, either with or without concurrent chemotherapy. Surgery was performed in collaboration with the surgical oncologist and urologist. Resection of the rectal tumor was performed by open abdominal or abdominoperineal approach. All patients underwent a complete cystectomy and a urinary diversion was performed by ileal or colon conduit. The surgical procedures were similar in both CZE and EMC, except for the administration of intra-operative radiation therapy (IORT) that was delivered as intra-operative external beam radiotherapy (IOERT) in the CZE and as intra-operative brachytherapy (IOBT) in the EMC. In the EMC, the choice for either a colon conduit or an ileal conduit was made during surgery and was based on practical considerations; there were no reasons for choosing one technique or the other from an oncological perspective. A colon conduit was the preferred technique when this would avoid the need to make an extra anastomosis. In practice, this meant that patients who were to receive an end colostomy were selected for the colon conduit technique. In case a primary low anastomosis could be performed or a colon conduit could not prevent an extra anastomosis, an ileal conduit was routinely performed. In the CZE, the preferred method was to perform an ileal conduit.

An ileal conduit was performed as previously described by Bricker et al. In summary, an ileal segment of approximately 15 cm was isolated at 10 cm distance from the valve of Bauhin, and a hand sewed or stapled ileo-ileal anastomosis was performed [9]. Both ureters were spatulated and then separately hand sutured in one layer with PDS 4-0 side-to-end into the ileal segment. Subsequently, the distal end of the conduit was delivered through the abdominal wall and was matured.

To create a colon conduit a colon segment of approximately 15 cm was isolated [10]. This segment was the distal segment of the descending colon that was already transected during a procedure in which the rectum was removed. Oxygenation of this segment was supplied by the left colonic artery, which means that a low tie of the inferior mesenteric artery was performed for the rectal resection. The colon conduit was often placed in the left hemiabdomen and the transverse colon was then mobilized to create a right-sided end colostomy, although colon conduits are usually mobile enough to facilitate placement on either side of the abdomen (Fig. 1). In some cases, the ureters were inserted in an already existing colostomy after which a new end colostomy was created for stool. Ureters were attached in the same way as described for Bricker's diversion. In both ileal and colon conduits single J stents (EMC 7 French and CZE 8 French) were placed in both ureters to ensure sufficient flow during the first 10 days. Stents were fixed to the bowel wall with 4-0 quickly absorbable braided sutures and led out through the ostomy. If no complications occurred stents were removed at day 9 and day 10 after surgery under antibiotic prophylaxis.

Complications

Short-term complications were defined as any complication within 30 days after surgery, during the primary hospital admission or during a readmission within 30 days. Long-term complications were defined as any complication that occurred more than 30 days after surgery, unless they occurred during the primary admission or a readmission within 30 days. Complications were graded according to the Clavien-Dindo classification [15]. Surgical and urological complications were identified from available data. Urological complications were defined as complications related to the urinary diversion or urogenitary tract or the ileo-ileal anastomosis performed for isolating the ileal conduit. Surgical complications were defined as any non-urological complication. A postoperative ileus was defined as two or more of the following: nausea/vomiting, inability to tolerate an oral diet, the absence of flatus, abdominal distention and/or radiological evidence of bowel distension without signs of a mechanical obstruction. During hospitalization, patients were daily observed for the occurrence of ileus. An anastomotic leakage was defined as a communication between the intra- and extraluminal compartments, determined by either clinical or radiologic evidence.

Statistical analysis

Continuous data were reported as median (interquartile range or 95% confidence interval) and categorical data were reported as count (percentage). Group comparisons were made using Chi-square or Mann-Whitney *U* test as appropriate. Long-term complication rates were calculated from the date of surgery until

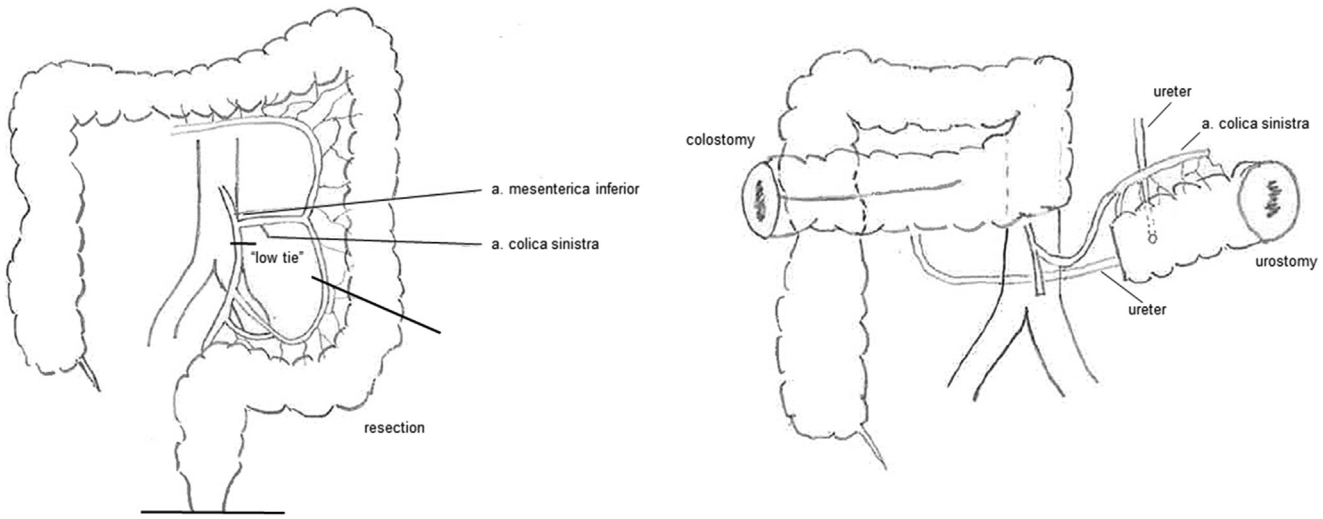

Fig. 1. Schematic presentation of performing a colon conduit.

Table 1
Baseline characteristics colon conduit vs ileal conduit.

		Total (N = 259)	Colon conduit (N = 45)	Ileal conduit (N = 214)	P-value
		N (%)	N (%)	N (%)	
Hospital	CZE	134 (52)	1 (2)	133 (62)	<0.001
	EMC	125 (48)	44 (98)	81 (38)	
Type of rectal cancer	LARC	131 (50)	28 (62)	103 (48)	0.086
	LRRC	128 (50)	17 (38)	111 (52)	
Gender	Female	45 (17)	7 (16)	38 (18)	0.723
	Male	214 (83)	38 (84)	176 (82)	
Age at resection	Median [IQR]	66.0 [58.0, 70.5]	66.0 [58.0, 70.0]	66.0 [58.0, 70.8]	0.937
ASA	I	42 (17)	7 (16)	35 (18)	0.944
	II	164 (67)	31 (69)	133 (67)	
	III	37 (15)	7 (16)	30 (15)	
Clinical tumor stage[a]	cT3	12 (9)	2 (7)	10 (10)	0.676
	cT4	119 (91)	26 (93)	93 (90)	
Clinical nodal stage	cN0	70 (46)	13 (37)	57 (48)	0.144
	cN1	34 (22)	12 (34)	22 (19)	
	cN2	49 (32)	10 (29)	39 (33)	
Clinical metastases	cM0	229 (88)	38 (84)	191 (89)	0.360
	cM1	30 (12)	7 (16)	23 (11)	
Neoadjuvant chemotherapy	No	213 (82)	40 (89)	173 (81)	0.199
	Yes[b]	46 (18)	5 (11)	41 (19)	
Neoadjuvant radiotherapy	None	25 (9)	4 (9)	21 (10)	0.113
	Radiotherapy	51 (20)	4 (9)	47 (22)	
	Chemoradiotherapy	182 (71)	37 (82)	145 (68)	
Interval radiotherapy – surgery (weeks)	Median [IQR]	11.0 [9.0, 15.0]	13.0 [10.0, 14.0]	11.0 [9.0, 15.0]	0.314

CZE: Catharina Hospital Eindhoven; EMC: Erasmus Medical Center; LARC: Locally advanced rectal cancer; LRRC: Locally recurrent rectal cancer.
[a] Only applicable for LARC.
[b] 35 out of 46 patients had received induction chemotherapy in addition to other neoadjuvant therapy and 11 patients had received solely chemotherapy. Percentages may not add up to 100% due to rounding.

the last visit to the outpatient clinic. Two-sided p-values ≤ 0.05 were considered statistically significant. Multivariable logistic regression analysis was performed using all variables from Table 1 and Table 2 with a p-value <0.1. Nephrectomy was not used as a covariable in multivariable analysis due to low patient numbers. Statistical analyses were performed using SPSS version 24.0 (SPSS Inc., Chicago, IL) and R version 3.5.1 (http://www.r-project.org).

Results

Baseline characteristics are shown in Table 1. A total of 259 patients with locally advanced (n = 131) or locally recurrent rectal cancer (n = 128) were included for analyses. An ileal conduit was performed in 214 patients and more frequently in the CZE (CZE n = 133, EMC = 81) and a colon conduit in 45 patients and more frequently in the EMC (CZE n = 1, EMC n = 44) ($p < 0.001$). No other significant baseline differences were observed.

Surgical results

Surgical characteristics are shown in Table 2. All patients underwent pelvic exenteration with a cystectomy and resection of the (recurrent) rectal tumor. The length of the conduit was similar for both ileal and colon conduit (median 15 cm, IQR 15–20 cm). Patients with a colon conduit more often received an end colostomy, whereas patients with an ileal conduit more often had an ostomy from previous surgery (e.g. end colostomy after resection for the primary tumor)($p = 0.040$). Colo-anal anastomoses were more often performed in patients with an ileal conduit ($p = 0.027$). The operation time was significantly shorter for patients receiving an

Table 2
Surgical results colon conduit vs ileal conduit.

		Total (N = 259)	Colon conduit (N = 45)	Ileal conduit (N = 214)	P-value
		N (%)	N (%)	N (%)	
Approach	Abdominal	109 (42)	19 (42)	90 (42)	0.984
	Abdominoperineal	150 (58)	26 (58)	124 (58)	
HIPEC	Yes	5 (2)	0 (0)	5 (2)	0.300
Synchronous metastases resection[a]	Yes	8 (27)	3 (43)	5 (22)	0.269
IORT	IOBT	41 (16)	16 (36)	25 (12)	<0.001
	IOERT	105 (41)	1 (2)	104 (49)	
	No	113 (44)	28 (62)	85 (40)	
Ureter resection	Yes	2 (1)	0 (0)	2 (1)	NA
Nephrectomy	Yes	3 (2)	1 (1)	2 (1)	0.075
Length conduit (cm)	Median [IQR]	15.0 [15.0, 20.0]	15.0 [15.0, 20.0]	15.0 [15.0, 20.0]	0.372
Ileo-ileal anastomosis for ileal conduit	No	NA	NA	4 (2)	NA
	Yes	NA	NA	210 (98)	
Colo-anal anastomosis	No	228 (88)	44 (98)	184 (86)	0.027
	Yes	31 (12)	1 (2)	30 (14)	
Additional anastomosis	No	240 (93)	43 (96)	197 (92)	0.413
	Yes	19 (7)	2 (4)	17 (8)	
Ostomy	No ostomy	4 (2)	0 (0)	4 (2)	0.040
	Pre-existing ostomy	101 (39)	13 (29)	88 (41)	
	Loop ostomy	29 (11)	2 (4)	27 (13)	
	End ostomy	125 (48)	30 (67)	95 (44)	
Blood loss (ml)	Median [IQR]	3200.0 [2125.0, 5500.0]	3000.0 [2200.0, 3600.0]	3400.0 [2100.0, 6625.0]	0.088
Operation time (min)	Median [IQR]	437.0 [362.5, 517.2]	510.0 [439.0, 620.0]	420.0 [351.0, 495.0]	<0.001

NA: Not applicable; HIPEC: Hyperthermic intraperitoneal chemotherapy; IORT: Intra-operative radiation therapy.
IOBT: intra-operative brachytherapy; IOERT: intra-operative external beam radiotherapy.
[a] Calculated as percentage of patients with synchronous metastases. Percentages may not add up to 100% due to rounding.

ileal conduit than for those receiving a colon conduit with 420 min [IQR 351–495 min] versus 510 min [IQR 439–620], respectively ($p < 0.001$).

Anastomosis

In 210/214 patients with an ileal conduit an ileo-ileal anastomosis was performed, and in four patients no anastomosis was required because the pre-existing end ileostomy was used as a conduit ($n = 1$) or a new end ileostomy was performed ($n = 3$). In 30 patients with an ileal conduit a colo-anal anastomosis was performed, and in 17 patients an additional anastomosis was performed due to an additional bowel resection. In patients with a colon conduit, one colo-anal anastomosis was performed and two additional anastomoses due to an additional bowel resection were performed.

Short-term surgical and urological complications

Short-term surgical and urological complications are displayed in Tables 3 and 4. There was no statistical difference in major complications (Clavien-Dindo ≥ 3) and mortality rates (30-day mortality or in-hospital mortality) for patients with an ileal conduit compared to a colon conduit. There was no difference between hospital stay, reintervention rates and readmission rates between both groups. A postoperative ileus occurred more often in patients with an ileal conduit compared to patients with a colon conduit (21 vs. 7%, $p = 0.024$, respectively), which remained significant after multivariable analysis ($p = 0.025$). In patients with a colon conduit a wound infection (perineal and/or abdominal) was observed more often than in patients with an ileal conduit (31% vs. 16%, $p = 0.006$), but this was not significant after multivariable analysis ($p = 0.37$). No significant differences were found when comparing the rate of urological complications or the reintervention rate for urologic complications between the two groups. Metabolic acidosis occurred in 6 patients (3%) with an ileal conduit, and did not occur in patients with a colon conduit ($p = 0.256$).

Anastomotic leakage occurred in 6/210 patients (3%) with an ileo-ileal anastomosis. Anastomotic leakage of the ureter anastomosis occurred in 14/214 patients (7%) with an ileal conduit and in 3/45 patients (7%) with a colon conduit ($p = 0.976$). Anastomotic leakage of the colo-anal anastomosis occurred in 7/30 patients (23%) with an ileal conduit. In the colon conduit group only one colo-anal anastomosis was performed without leakage. In both groups, no leakage of additional anastomoses was observed.

When comparing only patients who underwent a resection through abdominoperineal approach, a postoperative ileus was still more often observed in patients who received an ileal conduit compared with a colon conduit ($p = 0.028$). The wound infection rate did not differ. In a subanalysis comparing patients with LARC and LRRC, there were no significant differences in short-term surgical and urologic complications.

Long-term complications

Long-term complications are presented in Table 5. In 72% of the patients (186 patients, colon conduit $n = 44$, ileal conduit $n = 142$) long term complications after 30 days were registered. The median follow-up for survivors for long-term complications was 55 months (95% CI 55–65 months). No significant differences in long-term complications between both groups were observed. One patient (2%) with a colon conduit and five patients (4%) with an ileal conduit experienced metabolic acidosis ($p = 0.582$). Three (2%) out of 139 patients with an ileal conduit presented with a late anastomotic leakage of the ileo-ileal anastomosis, 2/142 patients (1%) with uretero-ileal conduit leakage, and 2/21 patients (9%) with leakage of the colo-anal anastomosis. Patients with a colon conduit did not experience anastomotic leakage 30 days after surgery. Twelve patients (9%) with an ileal conduit developed a fistula ($n = 8$ entero-cutaneous, $n = 4$ uretero-enteric) compared to four (9%) patients with a colon conduit ($p = 0.895$) (all entero-cutaneous). In a subanalysis, there were no significant differences in long-term surgical and urologic complications when comparing LARC with LRRC.

Table 3
Short-term general and surgical complications colon conduit vs ileal conduit.

	Total (N = 259)	Colon conduit (N = 45)	Ileal conduit (N = 214)	P-value
	N (%)	N (%)	N (%)	
30-day mortality	14 (5)	1 (2)	13 (6)	0.299
In-hospital mortality	26 (10)	3 (7)	23 (11)	0.408
Major complications (Clavien-Dindo ≥ 3)	101 (39)	14 (31)	87 (41)	0.233
Any reintervention	90 (35)	11 (24)	79 (37)	0.110
Ileus	48 (19)	3 (7)	45 (21)	0.024
Wound infection (abdominal & perineal)	44 (17)	14 (31)	30 (14)	0.006
Pre-sacral abscess	47 (18)	7 (16)	40 (19)	0.620
Abdominal abscess	31 (12)	4 (9)	27 (13)	0.484
Ostomy complication	4 (2)	0 (0)	4 (2)	0.355
Fistula	6 (2)	1 (2)	5 (2)	0.963
Hospital stay in days (median [IQR])	14.0 [11.0, 18.5]	13.0 [11.0, 19.0]	14.0 [10.0, 18.0]	0.859
No readmission	217 (83)	36 (80)	179 (84)	0.230
Urological readmission	11 (4)	4 (9)	7 (3)	
Non-urological readmission	33 (13)	5 (11)	28 (13)	

Percentages may not add up to 100% due to rounding.

Table 4
Short-term urological complications colon conduit vs ileal conduit.

	Total (N = 259)	Colon conduit (N = 45)	Ileal conduit (N = 214)	P-value
	N (%)	N (%)	N (%)	
Urological complication	58 (22)	7 (16)	51 (24)	0.226
Urological reintervention	35 (14)	4 (9)	31 (14)	0.318
Urosepsis	9 (3)	1 (2)	8 (4)	0.614
Metabolic acidosis	6 (2)	0 (0)	6 (3)	0.256
Urinoma	12 (5)	2 (4)	10 (5)	0.947
Urinoma drainage	9 (3)	2 (4)	7 (3)	0.696
Urostomy complication	4 (2)	1 (2)	3 (1)	0.685
Hydronefrosis	22 (8)	1 (2)	21 (10)	0.097
Ureter stenosis	7 (3)	0 (0)	7 (3)	0.609
Urinary tract infection	16 (6)	3 (7)	13 (6)	0.881
Leakage ileo-ileal anastomosis [a]				
No	NA	NA	204 (97)	NA
Yes	NA	NA	6 (3)	
Leakage ureter - conduit anastomoses [a]				
No	242 (93)	42 (93)	200 (93)	0.976
Yes	17 (7)	3 (7)	14 (7)	
Leakage colo-anal anastomosis [a]				
No	24 (77)	1 (100)	23 (77)	0.538
Yes	7 (23)	0 (0)	7 (23)	
Leakage other anastomosis [a]				
No	19 (100)	2 (100)	17 (100)	NA
Yes	0 (0)	0 (0)	0 (0)	

NA: Not applicable.
Percentages may not add up to 100% due to rounding.
[a] Percentage of anastomotic leakage is calculated of patients in which a specific anastomosis was performed.

Discussion

The present pooled retrospective cohort of 259 patients undergoing total pelvic exenteration with urinary diversion for LARC and LRRC describes few differences in surgical and urological complications between a colon conduit and an ileal conduit. However, the formation of a colon conduit avoids the risk of ileo-ileal anastomotic leakage, which was 4% in this cohort. In addition, an ileal conduit appears to be associated with a higher post-operative ileus rate.

Several studies reported on outcomes after multivisceral surgery with cystectomy and the formation of a urinary diversion. However, complications are usually described for all types of pelvic cancer, and as outcomes may differ for different types of cancer this complicates comparison between studies. In the case of LARC and LRRC, a complete *en bloc* bladder removal with the rectal tumor is often performed, which makes it prone to other complications than after primary cystectomy alone [16,17]. A recent study by Bolmstrand et al. described complications after urinary tract reconstruction in colorectal and anal cancer after partial or complete cystectomy [13]. They reported a rate of 35% major complications (Clavien-Dindo≥3), which is comparable with the 39% in our series. The rate of intestinal anastomotic leakage was 9% in their series compared to 7% in our study. In the present study we did not find a significant difference when comparing the anastomotic leakages separately between the two types of conduit. However, 9 patients with an ileal conduit had an anastomotic leakage of the ileo-ileal anastomosis which is obviously ruled out when a colon conduit is performed.

Teixeira et al. compared outcomes in 74 patients who received an ileal or a colon conduit for different types of pelvic malignancies [12]. Their study did not find significant differences for complications assessed separately, such as urinary leaks, small bowel fistula, sepsis or drained collections. However, when all complications were combined, a significantly higher incidence of complications in patients with an ileal conduit compared to a colon conduit was

Table 5
Long-term complications colon conduit vs ileal conduit.

	Total (N = 186)	Colon conduit (N = 44)	Ileal conduit (N = 142)	P-value
	N (%)	N (%)	N (%)	
Urological complication	37 (20)	6 (14)	31 (22)	0.234
Urological reintervention	22 (12)	5 (11)	17 (12)	0.913
Urosepsis	4 (2)	1 (2)	3 (2)	0.949
Metabolic acidosis	6 (3)	1 (2)	5 (4)	0.682
Hydronefrosis	19 (10)	3 (7)	16 (11)	0.394
Percutaneous nephrostomy drainage	14 (7)	2 (5)	12 (9)	0.319
Urinary tract infection	19 (10)	4 (9)	15 (11)	0.778
Urinoma	0 (0)	0 (0)	0 (0)	NA
Ureter stenosis	16 (9)	4 (9)	12 (9)	0.895
Revision ureter stenosis	3 (2)	2 (5)	1 (1)	0.076
Revision urostomy	4 (2)	2 (5)	2 (1)	0.207
Fistula	16 (9)	4 (9)	12 (9)	0.895
Leakage ileo-ileal anastomosis[a]				
No	NA	NA	136 (98)	NA
Yes	NA	NA	3 (2)	
Leakage ureter - conduit anastomoses[a]				
No	184 (99)	44 (100)	140 (99)	0.429
Yes	2 (1)	0 (0)	2 (1)	
Leakage colo-anal anastomosis[a]				
No	20 (91)	1 (100)	19 (91)	0.746
Yes	2 (9)	0 (0)	2 (9)	

NA: Not applicable. Percentages may not add up to 100% due to rounding.
[a] Percentage of anastomotic leakage is calculated of patients in which a specific anastomosis was performed.

found (40% vs. 19%, respectively, $p < 0.01$) [12]. In the present study, a postoperative ileus was observed significantly more often in patients with an ileal conduit compared to patients with a colon conduit (21% vs 7%, $p = 0.024$). Prolonged duration of ileus is a known complication after formation of an ileal conduit and may lead to a prolonged hospitalization [8,18]. In CZE, patients are frequently transferred to referring hospitals when they are clinically stable. This may have led to an underestimation of the hospital stay in patients treated in the CZE.

The proportion of patients with a wound infection (abdominal and/or perineal) was significantly higher in patients with a colon conduit. Several factors may influence wound healing such as surgical approach, extent of surgery, perineal or abdominal reconstruction (i.e. muscle flap reconstruction, omentoplasty), patient characteristics or even bacterial load from the conduit. This could not be explained clearly with the available data and multivariate analysis no longer showed a significant difference between groups.

Despite the possible favorable outcomes in terms of complications, and the fact that previous studies showed a low tie can be safely performed regarding oncological outcomes, a colon conduit is not always technically possible to perform [19,20]. For example, in case of macroscopic lymph node metastasis above the level of the left colic artery a high tie must be performed and a colon conduit can only be created when the blood supply via the middle colic artery and Riolan's arcade conduit is sufficient. Furthermore, in patients with LRRC a repeated resection of the descending colon can result in insufficient length and blood supply for the creation of a colon conduit.

In addition to an ileal or colon conduit, the formation of other types of urinary diversion such as an Indiana pouch, neobladder or double-barrelled wet colostomy are technically possible as well. However, in CZE and EMC reconstructions using an Indiana pouch or neobladder are not performed in patients with extensive colorectal malignancy as these reconstructions are associated with a higher complication rate in these patients [17]. The double-barrelled wet colostomy (DBWC) inherently has a benefit over the ileal or colon conduit, as it requires only one stoma. However, in our experience this type of diversion is unpleasant to take care of for patients and subsequently has a negative impact on the quality of life. Therefore, a DBWC is not performed in our institutions.

This study is limited by its retrospective nature. Improvement in multimodality treatment such as neoadjuvant therapies over the last decades may influence our results, but the majority of patients in our study were treated with neoadjuvant (chemo-)radiotherapy and there was no significant difference between both groups. Although treatment protocols are similar in both hospitals, there is an imbalance in the proportion of patients with an ileal or colon conduit, as CZE only performed one colon conduit. Also, the admission of IORT is different in both hospitals; in CZE IOERT is administered whereas in EMC IOBT is administered. The significant difference in operation time between the ileal and colon conduit may be explained by the administration of mainly IOBT in the colon conduit group, as this is a more time-consuming procedure than IOERT. For the same reason, IOBT was only applied in case of positive fresh frozen sections, whereas IOERT was also administered in case of clinically threatened margins. Since a larger proportion of patients in this cohort was treated in the CZE where an ileal conduit was the preferred method, IORT was most frequently used in patients with an ileal conduit.

The use of an intestinal segment as urinary conduit may lead to metabolic changes, which may depend on the length and type of the conduit, ileal or colonic [8,14,21]. In the literature, a colon conduit is more often associated with metabolic acidosis than an ileal conduit. This study did not find a significant difference, although metabolic acidosis may be underreported.

Long-term follow-up was available in 70% of the patients with a wide range of follow-up time. Despite these limitations, this study still provides valuable information for the use of both an ileal and colon conduit.

Conclusion

The formation of an ileal or colon conduit in patients undergoing total pelvic exenteration for LARC or LRRC has similar urologic complications. However, the formation of a colon conduit rules out ileo-ileal anastomotic leakage. Besides, an ileus was more frequently seen after the formation of an ileal conduit in this study. Therefore, the colon conduit may be a feasible alternative for an ileal conduit in patients receiving an end colostomy.

Declaration of competing interest

None.

CRediT authorship contribution statement

J.A.W. Hagemans: Conceptualization, Methodology, Investigation, Formal analysis, Writing - original draft, Writing - review & editing. **E.L.K. Voogt:** Conceptualization, Methodology, Investigation, Formal analysis, Writing - original draft, Writing - review & editing. **J. Rothbarth:** Methodology, Resources, Writing - review & editing. **G.A.P. Nieuwenhuijzen:** Resources, Writing - review & editing. **W.J. Kirkels:** Writing - review & editing. **J.L. Boormans:** Writing - review & editing. **E.L. Koldewijn:** Writing - review & editing. **R. Richardson:** Writing - review & editing. **C. Verhoef:** Conceptualization, Methodology, Resources, Writing - review & editing. **H.J.T. Rutten:** Methodology, Resources, Writing - review & editing. **J.W.A. Burger:** Conceptualization, Methodology, Resources, Writing - review & editing, Supervision.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ejso.2020.02.021.

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